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A critical evaluation of soil water retention parameterizations with respect to their behaviour near saturation and in the dry range

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Flow of liquid water and movement of water vapor in the unsaturated zone affect in-soil processes (e.g., root water uptake) and exchanges of water between the soil and the groundwater (e.g., aquifer recharge) and between the soil and the atmosphere (e.g., evaporation). Evapotranspiration in particular is a key factor in the way soils moderate weather and respond to climate change. Soil physicists typically model these processes at scales of individual fields and smaller. They solve Richards' equation using soil water retention curves and hydraulic conductivity curves (soil hydraulic property curves) that are typically valid for even smaller soil volumes. Over the years, many parametric expressions have been proposed as models for the soil hydraulic property curves.

Before Richards' equation and the associated soil hydraulic properties can be upscaled or modified for use on scales that are more useful for climate modeling and other applications of practical relevance, the small scale soil hydraulic property curves should at least perform well on the scale for which they were originally developed. Research over the past couple of decades revealed that the fit of soil water retention curves in the dry end is often quite poor, which is particularly risky when vapor flow is a significant factor. It also emerged that the shape of the retention curve for matric potentials very close to zero can generate physically unrealistic behavior of the hydraulic conductivity near saturation when combined with a popular class of conductivity models.

We critically examined most of the existing soil water retention parameterizations with respect to these two aspects, and introduced minor modifications to a few of them to improve their performance. The presentation will highlight the results of this review, and demonstrate the effect on calculated fluxes of liquid water and water vapor in soils for illustrative hypothetical scenarios.